Growth and Propagation of Common Carp (*Cyprinus carpio* L.) in India—V

Observations on the size of eggs, hatchlings and fry of parents of various size[1]

BY

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Introduction

A stock of common carp, originally imported from Prussia, was introduced into India in 1939 (Chacko 1945). Left to breed naturally in the Nilgiri waters, this stock comprises a mixture of mirror carp (*C. carpio* var. *specularis*), scale carp (*C. carpio* var. *communis*) and leather carp (*C. carpio* var. *nudus*)—the three commonly recognised varieties of this cosmopolitan species which has the distinction of being the most widely cultivated fish in the world. Though subsequently introduced into other parts of the country this stock has been mostly confined to the relatively cold, upland waters where all the varieties have been freely breeding. In the warmer waters of the Indian plains it was not found to breed freely and its utility as a pond fish for the plains, therefore, remained relatively unexplored.

A consignment of common carp that breeds freely in the South-East Asian countries was brought to Cuttack in 1957 with a view to try its utility for cultivation in the Indian plains (Alikunhi *et al.*—unpublished). These are pure scalers (*C. carpio* var. *communis*) and have been breeding prolifically at Cuttack since March, 1958.

Repeated observations at Cuttack have shown that under normal pond conditions this fish matures when it is 18-20 cm. long and weighs about 0·12 kg. Fishes ranging up to 6·0 kg. and over are now used in experimental as well as commercial breeding at Cuttack. During

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this work differences in the size of eggs, hatchlings and fry of parents of different size were frequently observed and it was felt necessary to examine this carefully and ascertain whether such differences, if they really exist, are of any cultural significance. During the period 1960-63 fifty-two pairs of common carp of selected size were specially bred to study the eggs, hatchlings and fry and these observations are recorded in the present paper.

Material and Methods

The length and weight of the female and male breeders were recorded when fishes were kept in *hapas*[1] for breeding. For purposes of this study single females were mated with single males of comparable size so that parentage of the entire batch of eggs was definite. Laid eggs sticking on to weeds kept in the *hapas* were collected and random samples measured under the microscope. Samples on weeds were kept in enamel trays, in tap water and in pond water in the laboratory. When the eggs started hatching 50 to 100 hatchlings were collected, generally within 4 to 6 hours of hatching and their total length was measured. At the same time 50 to 100 hatchlings from the hatching *hapa* fixed in the pond were also taken and measured for purposes of comparison.

To find out whether fry from parents of markedly different size show differences in growth when reared under identical conditions, samples of fry were reared in laboratory aquaria for periods of 20 days. At the end of the period surviving fry in different aquaria were fixed, measured and weighed.

Observations and Results

Eggs : When a representative sample of fertilised eggs from a batch is examined we find them falling within a particular range of size. Eggs from large females also appear larger than those from smaller females. The range of size and frequency of each size of eggs from 52 selected specimens arranged in 5 size groups at 10 cm. intervals are given in Table I.

Diameter of the eggs, excluding the vitelline space and egg membrane was measured under the microscope. The samples were arbitrarily divided into 4 groups of almost equal range and analysed. It is seen from the table that in the smaller fish the proportion of the smaller eggs is predominant and that as the size of the female increases the diameter of the predominant group of eggs also increases. The first group of

[1] Rectangular cloth tanks of various size, supported by bamboo poles at corners.

TABLE I

RANGE AND FREQUENCY OF SIZE OF LAID EGGS OF *Cyprinus carpio* IN RELATION TO THE SIZE OF THE FEMALE

Group	No. Examined	*Female* Length (cm.)		*Female* Weight (kg.)		Diameter of laid eggs (mm.)		% of eggs in dia. group (mm.)			
		Range	Av.	Range	Av.	Range	Av.	I up to 1·18	II 1·18-1·36	III 1·36-1·54	IV 1·54+
1.	9	15·0-25·0	20·34	0·119-0·398	0·200	0·90-1·51	1·21	50	46	4	—
2.	7	26·0-35·0	31·12	0·334-0·767	0·631	0·96-1·51	1·23	27	57	16	—
3.	12	36·0-45·0	40·65	1·122-1·925	1·389	1·01-1·65	1·32	6	63	30	1
4.	15	46·0-55·0	50·75	2·200-4·540	3·016	1·01-1·56	1·34	4	46	49	1
5.	9	56·0-65·0	59·21	3·973-6·129	4·769	1·10-1·65	1·41	2	23	67	8

eggs up to 1·18 mm. in diameter progressively becomes scarce (50% to 2%) as the weight of the parent fish increases to 4-6 kg. Likewise, the proportion of the larger eggs (group II & III) steadily increases with the size of the parent. In the 15 to 35 cm. length range of females the largest diameter of eggs encountered was only 1·51 mm. While the average length of the female breeder increases from 20 to 59 cm., the average diameter of the laid eggs increases from 1·21 mm. to 1·41 mm. This actual increase by 0·20 mm. represents 16·5% increase in diameter. In terms of volume of the egg and consequent quantity of stored up material in the egg the increase averages 58%.

Soon after fertilization the egg swells up by water absorption and a narrow vitelline space appears between the egg and its surrounding vitelline membrane. The overall diameter of the fully swollen egg shows some variations, depending perhaps on the conditions of the medium, but even here progressive increase in size is evident as the size of the parent increases (Table II).

TABLE II

OVERALL DIAMETER OF FULLY SWOLLEN EGGS OF *C. carpio* IN RELATION TO SIZE OF THE FEMALE

Group No.	Female		*Av. Diameter (mm.) of egg*	
	Average length (cm.)	Average weight (kg.)	Excl. vit. space	Including vit. space
1.	20·34	0·200	1·21	1·51
2.	31·12	0·631	1·23	1·65
3.	40·65	1·389	1·32	1·64
4.	50·75	3·016	1·34	1·70
5.	59·21	4·769	1·41	1·73

The average increase in diameter of the fully swollen egg is 14·5% from the first to the fifth group and the corresponding increase in volume is almost 46% ; both very much similar to the respective increase in the case of the egg excluding the vitelline space.

Hatchlings : Measurements of hatchlings from parents of different size also show, as in the case of eggs, a progressive increase in length (Table III).

Hatchlings obtained by keeping developing eggs in pond water in trays in the laboratory were used for the above measurements. As stated earlier the samples were fixed 4-6 hours after hatching com-

TABLE III

RANGE AND FREQUENCY OF SIZES OF HATCHLINGS OF *C. carpio* IN RELATION TO THE SIZE OF THE FEMALE BREEDERS

Size group of female breeder[1]	Length in mm. of hatchlings		% of hatchlings in size groups (mm.)			
	Range	*Average*	I up to 4·72	II 4·72 to 5·44	III 5·44 to 6·16	IV above 6·16
1.	4·40-5·68	4·99	11	82	7	..
2.	4·03-5·31	4·76	36	64	..	..
3.	3·76-5·68	4·83	30	69	1	..
4.	3·66-5·95	4·77	45	40	15	..
5.	3·66-5·86	5·00	26	51	23	..

[1] Length and weight of breeders same as in groups 1 to 5 of Table I.

menced. When the hatching is prolonged the samples are likely to include a few newly hatched larvae also, irrespective of the size of the parent. In spite of this the gradually increasing trend is clear and the percentage of larger hatchlings (group III) increases as the size of the female parent increases.

Hatchlings just emerging from the eggs were collected and measured in two batches taken from parents of different sizes and were analysed (Table IV).

The Table shows that the hatchlings of the larger fish are nearly $\frac{1}{8}$th longer than those of the smaller fish. In the same batch of hatchlings the largest one is generally 20 to 24% longer than the smallest one. Further, smaller hatchlings predominate in the case of the smaller fish while, in the larger fish the smaller hatchlings are relatively very few, the larger ones predominating.

Size of Hatchlings in Different Media : It was noted that when eggs from the same batch are hatched under different conditions and in different media the length of the hatchlings varied markedly. When hatched in cloth *hapas* fixed in the pond and in pond water and in tap water in trays in the laboratory, the length of hatchlings varies (Table V).

While the pond water is alkaline in pH and rich in nutrients, tap water is acidic or neutral in pH and poor in nutrients. Water temperature in the pond was also consistently higher than that in trays in the laboratory. Pond water and tap water in trays in the laboratory had identical temperature though dissolved nutrients, gases and pH were different. It is possible that under the above conditions of pond water there is better utilisation of yolk.

Irrespective of the environment in which the eggs were hatched the average length of the hatchlings increases with the increase in size of the female parent. This trend is evident even at the end of the second day after hatching when the stored-up yolk has been fully utilised by the hatchling. The hatchlings from the pond are about 14% longer than hatchlings in pond water in trays in the laboratory. When measurements of representative samples of hatchlings from different broods of eggs are arranged in groups the relative abundance of these groups indicate the same trend as in the case of eggs (Table VI).

Under laboratory conditions as well as in the pond the length of hatchlings increases with the increasing size of the parent. The smaller hatchlings in groups I and II steadily become scarce in broods from parents of groups 4 and 5. Under laboratory conditions, the average length of hatchlings being shorter the above trend is not so obviously brought out as under pond conditions.

Survival and Growth of Hatchlings : As hatchlings from eggs of large breeders were generally larger than those from smaller breeders, attempts

TABLE IV

RANGE AND FREQUENCY OF SIZES OF EGGS AND HATCHLINGS FROM TWO FEMALE BREEDERS OF *C. carpio* OF DIFFERENT SIZE

Size of Female		Diameter of eggs Excl. vit. space (mm.)		Frequency (%) of sizes (mm.)			Hatchlings in pond water in the lab. length (mm.)		Frequency % of sizes (mm.)		
Length (cm.)	*Weight* (kg.)	*Range*	*Average*	I up to 1·18	II 1·18-1·36	III 1·36-1·54	*Range*	*Average*	I up to 4·72	II 4·72-5·44	III 5·44-6·16
37·6	1·12	1·15-1·42	1·27	8	84	8	4·48-5·31	4·93	76	24	..
60·5	4·17	1·28-1·56	1·42	..	16	76[1]	4·70-5·95	5·41	6	58	36

[1] 8% of the eggs larger than size III.

TABLE V

SIZE RANGE OF HATCHLINGS OF *C. carpio* WHEN EGGS ARE HATCHED IN DIFFERENT ENVIRONMENTS

♀ Parent's size group	*Range and Average length of hatchlings (mm.) in the*			*Range and Average length of hatchlings (mm.) after yolk absorption in the*		
	Pond	*Laboratory*		*Pond*	*Laboratory*	
		in pond water	in tap water		in pond water	in tap water
1.	4·03-6·41 (5·14)	4·40-5·68 (4·99)	3·30-6·05 (4·38)	4·85-6·87 (6·26)	3·76-6·76 (5·76)	3·94-6·69 (5·67)
2.	4·58-6·14 (5·59)	4·03-5·31 (4·76)	3·00-5·22 (4·55)	5·59-6·96 (6·48)	3·66-7·14 (6·17)	4·03-6·50 (5·54)
3.	4·03-6·05 (5·11)	3·76-5·68 (4·83)	3·39-5·50 (4·57)	5·50-7·42 (6·51)	4·40-6·78 (5·76)	4·55-6·60 (5·52)
4.	3·94-6·69 (5·28)	3·66-5·95 (4·77)	3·21-6·05 (4·75)	5·68-7·33 (6·56)	4·03-7·23 (5·96)	4·58-5·86 (5·40)
5.	3·85-6·60 (5·70)	3·66-5·86 (5·00)	4·12-5·77 (5·06)	5·56-7·67 (6·66)	4·95-6·87 (5·96)	..

TABLE VI

FREQUENCY OF DIFFERENT SIZE GROUPS OF HATCHLINGS IN RELATION TO THE SIZE OF PARENTS

Female Parent Group No.	Hatchlings in *hapa* in the pond				Hatchlings in trays in the laboratory							
	Percentage of size groups (mm.)				Percentage of size groups (mm.) *In pond Water*				Percentage of size groups (mm.) *In tap Water*			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	33	27	37	3	11	82	7	..	86	10	4	..
2.	..	27	73	..	36	64	..	..	62	38	..	..
3.	25	37	38	..	30	69	1	..	66	34	..	..
4.	23	32	40	5	45	40	15	..	51	43	6	..
5.	11	7	73	9	26	51	23	..	14	66	20	..

Note : I=up to 4·72 mm. ; II=4·72 to 5·44 mm. ; III=5·44 to 6·16 mm. ; IV=Over 6·16 mm.

were made to determine whether this initial advantage in length is of any significance in their early growth and survival. Fishes of widely different weights were artificially spawned under identical conditions and the eggs were also hatched under identical conditions. Ten litre capacity glass aquaria with equal quantity of filtered pond water were set up and at 100 fry per aquarium three random lots from each brood of fry were kept for rearing. The fry in various aquaria were fed daily with identical quantities of fresh zoo-plankton. Survival and growth of fry at the end of 20 days of rearing are given in Table VII.

TABLE VII

C. carpio, SURVIVAL AND GROWTH OF FRY FROM PARENTS OF DIFFERENT SIZE

No.	Size of ♀ Parent		Av. size of fry at stocking		Av. size attained in 20 days		Survival %
	Length (cm.)	Weight (kg)	Length (mm.)	Weight (mg.)	Length (mm.)	Weight (mg.)	
1.	21·2	0·243	5·92	0·96	14·25	25·1	94
2.	29·6	0·643	7·08	1·70	15·95	40·8	87
3.	50·4	3·165	7·45	2·64	16·51	48·3	86
4.	57·7	3·748	6·53	1·70	14·89	24·3	99

Specimens 1-4 and 2-3, with similar size males formed the sets of breeders from which fry were obtained for simultaneous rearing. Though several more such lots have to be reared in the laboratory and also in the field before reliable conclusions can be drawn, the preliminary results indicate that under comparable conditions fry of the larger breeders grow slightly faster than those of the smaller fish. At commencement of rearing the fry of the two larger fish were about 7·5% larger than the fry of the smaller fish. After 20 days of rearing they remained longer by only 4%. By weight, the fry of the larger fish were about 55% heavier at commencement of rearing, than those of the smaller fish. At the end of the rearing period, this difference was appreciably reduced and they were only about 10% heavier than the fry of the smaller fish. However, when the actual increase in length and weight is compared with the initial length and weight of fry in each case, we find, in this particular series, the fry of the smaller parents growing better, though with a slightly lower survival. Prevezentsev (1964) studying the size, weight and chemical composition of eggs and larvae of 4, 7 and 10 year old spawners found best indices for the offspring of average size spawners and poorest for those of first time spawners.

Discussion

According to Martyshev (Quoted by Nikolsky, 1963) in the carp, *C. carpio* L., the largest broods are those produced by fishes of age 8+ ; the young and older individuals produce less viable young. Depending on the age of the fish the diameter of eggs and length of hatchlings also vary as follows (Nikolsky, 1963, p. 173).

	Age of carps in years			
	3 +	4 +	8 +	17+
Average diameter of eggs (mm.)	1·26	1·39	1·71	1·64
Average length of hatchlings (mm.)	4·80	5·05	6·41	6·18

Observations recorded in the present paper show a similar correlation of the length and weight of the fish with the size of eggs and hatchlings as follows :

Average size of breeder		Av. diameter of eggs (mm.)	Average length of hatchling (mm.)
Length (cm.)	Weight (kg.)		
20·0	0·20	1·21	5·14
31·0	0·63	1·23	5·59
41·0	1·39	1·32	5·11
51·0	3·02	1·34	5·28
59·0	3·75	1·41	5·70

Careful analysis of the batches of eggs laid by breeders of different size has shown : (*a*) an appreciable range in the size of eggs ; (*b*) a predominance of a particular size correlated with the size of the breeder and, (*c*) presence often of a low percentage of relatively large eggs. This applies in the case of hatchlings as well.

The occurrence of a limited number of fast growing fry in a batch hatched from a parent has been repeatedly observed in common carp. In the case of Indian carps, *Catla*, *Rohu* and *Mrigal* also such fast growing specimens appear when batches of fry from a brood are reared in ponds. In Japan such fast growing carps are called '*Tobi-Koi*' or '*Shoot carps*' (Matsui 1949, Nakamura & Kasahara 1955). Matsui (1949, 1950) is of the view that these '*shoot carps*' can be distinguished from normal specimens of *C. carpio* by morphological characteristics which are of genetic significance and which could, therefore, be fixed by selective breeding to yield a faster growing strain. Nakamura &

Kasahara (1955, 1956, & 1957) have tried to show that competition for food between individual fry within a batch is an important causative factor for the occurrence of '*shoot carps*' and as such these fast-growing specimens may not be of genetic significance.

If we concede that the fry of the larger parent (generally of a larger average size) grow faster than the fry of the smaller parent (generally of a lower average size) (Nikolsky, 1963) it may be possible to infer that the relatively small percentage of larger hatchlings in a batch would grow faster than the rest in the batch. If this could explain the occurrence of '*shoot carps*' then it might possibly be of some genetic significance. Particle size, paucity of food and competition result in extreme skewness in the batches of fry reared in ponds but it also shows that a few of the fry in the batch have greater capacity to ingest and assimilate food than others and it is yet to be ascertained if this capacity could be fixed.

The observation that eggs of the same batch hatched in different media under other identical conditions result in hatchlings of different size would indicate that in ponds with widely differing water conditions, the hatchlings of carp of a particular size could be of different sizes. Selective breeding and extensive progency testing (Wohlfarth *et al.*, 1961) have to be carried out in order to arrive at tangible results out of trends indicated in this paper.

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